Forward Models can be Inferred from EEG Data

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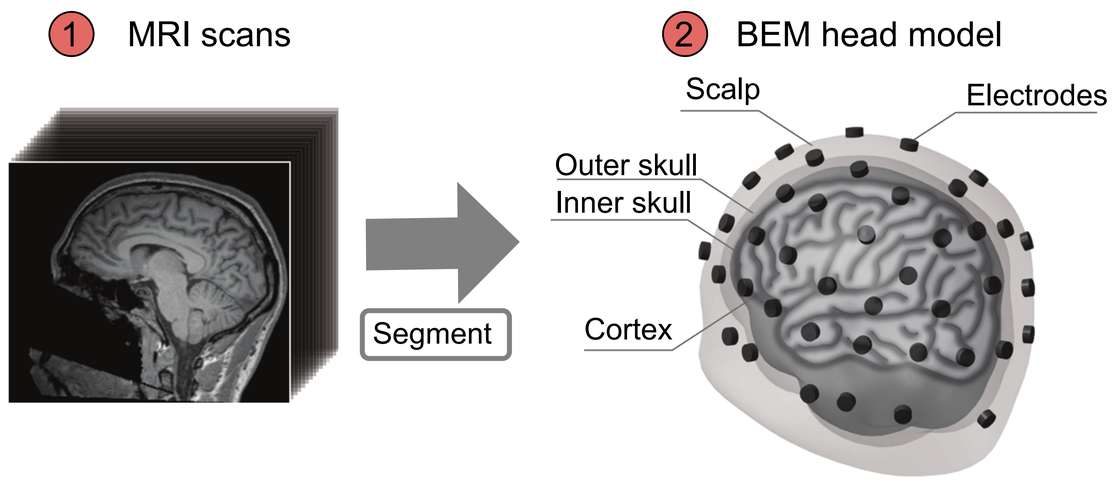
MOTIVATION

Accurate 3D EEG imaging is contingent on a suitable forward model [1, 2]. The forward model describes the propagation path of the EEG sources to the EEG sensors [3]. Forward models are estimated based on head geometry and conductivity assumptions thus requiring subject-specific information. We propose an alternative: Learn a forward model based on the EEG data of the subject and a data-driven prior over forward models.

FORWARD MODEL REPRESENTATION

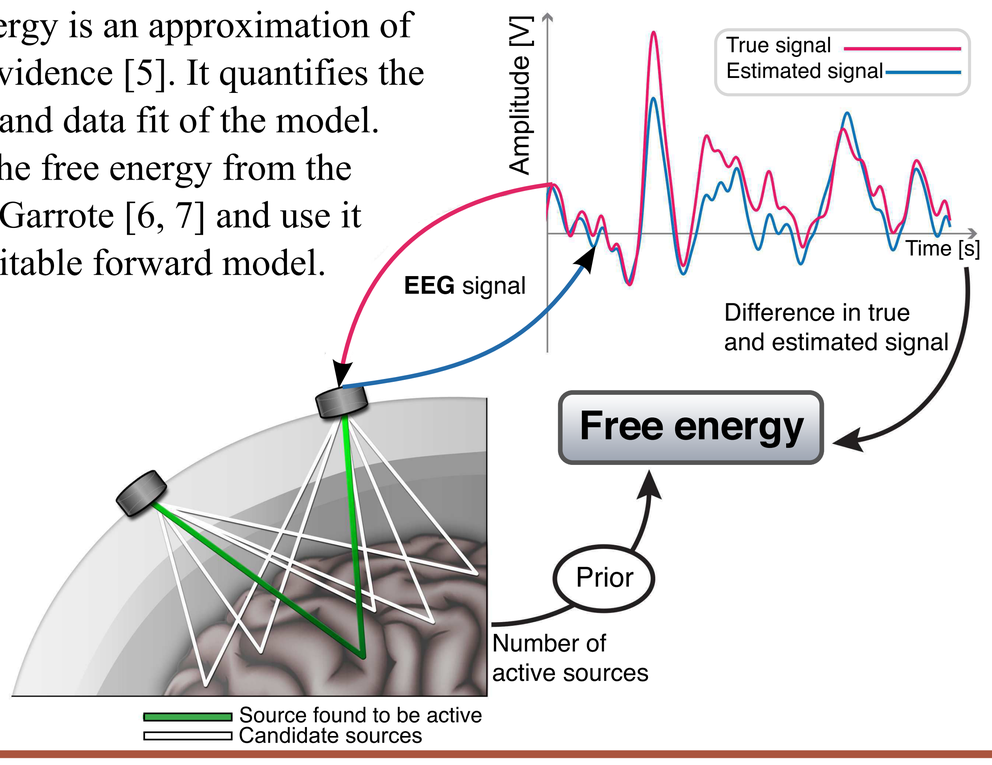


3 PCA representation of forward model corpus

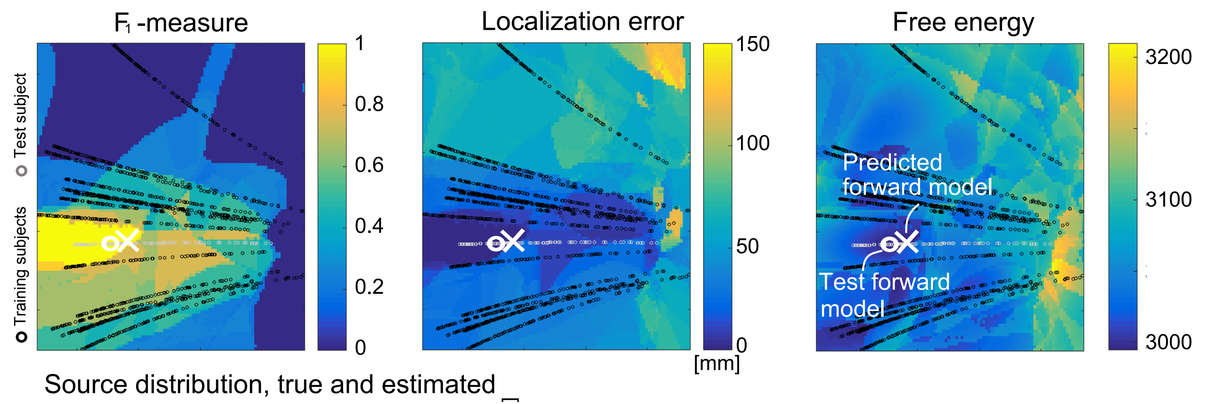
1. Structural scans of 16 subjects are obtained from the multi-subject multimodal neuroimaging dataset [4].
2. The sMRIs are for each subject segmented into cortex, skull and scalp.
3. Each head model is combined with different skull:soft tissue conductivity ratios, generating 100 forward models for each subject. The forward model corpus is decomposed using principal component analysis.

FORWARD MODEL INFERENCE

The free energy is an approximation of the model evidence [5]. It quantifies the complexity and data fit of the model. We obtain the free energy from the Variational Garrote [6, 7] and use it to infer a suitable forward model.

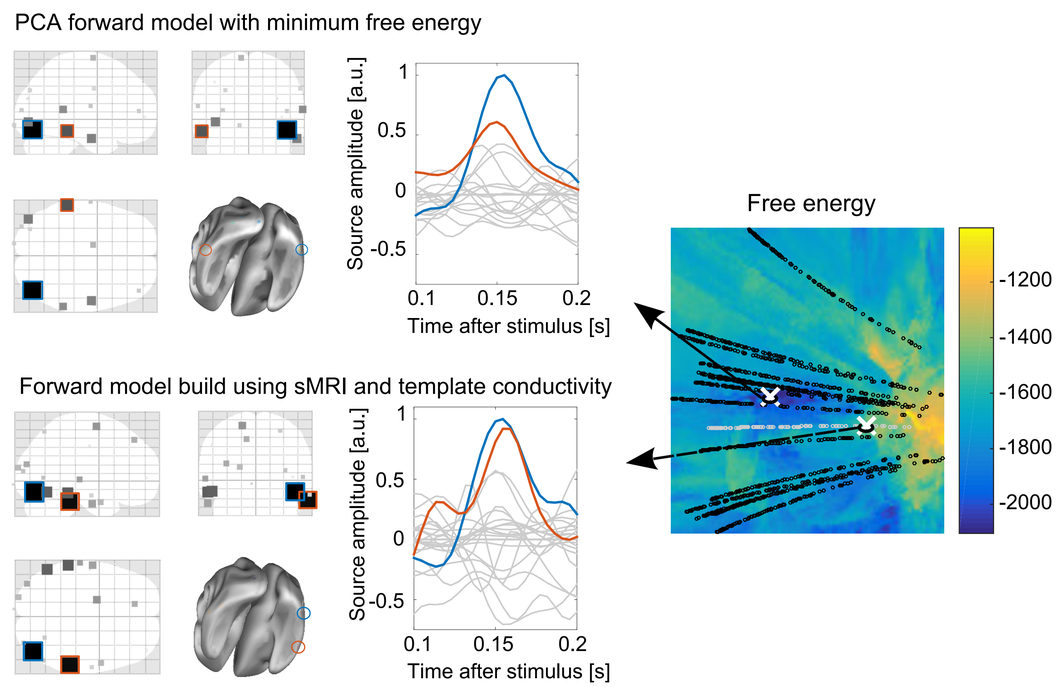


SIMULATION RECOVER A FORWARD MODEL FOR A NEW SUBJECT



Forward model build using:	PCA prior, EEG data	Template head, template σ	Subject sMRI, template σ	Subject sMRI, true σ
Free energy	2994	3192	3057	2956
MSE	0.63	0.55	0.93	0.61
F_1-measure	1	0	0.44	0.5
Localization error	0	19.6 mm	5.3 mm	2.9 mm

REAL EEG DATA - FACE PERCEPTION TASK



CONCLUSION

- The proposed framework provides simultaneous estimation of a forward model and the EEG sources.
- Forward models can be inferred for new subjects without subject-specific geometry and conductivity. Instead inference is based on a forward model representation and the recorded EEG of the new subjects.
- Inferred forward models provides similar source distributions as when using forward models having structural information.

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For more information check out: Hansen, S.T., Hauberg, S., Hansen, L.K. (2016). Data-driven forward model inference for EEG brain imaging. *NeuroImage*, in press. doi:10.1016/j.neuroimage.2016.06.017